Testing waterspout forecasting indices over the Adriatic sea using ALADIN model

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1. Introduction

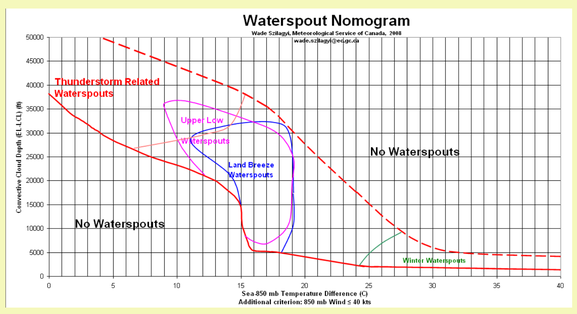
Several waterspout events occur in Croatia every year. This has motivated us to develop and test a waterspout forecasting tool. Forecasting waterspout events is of great importance since they can be dangerous and cause damage, especially in a case of landfall. In the literature two forecasting indices are most often mentioned, the Szilagyi Waterspout Index (SWI) and the Kuiper and van der Haven waterspout index (KHS). Both indices calculate risk of (water)spout development.
In this study these two indices will be tested on several waterspout cases along the Croatian coast of the Adriatic sea.
The Szilagyi Waterspout Index (SWI) is based on the Szilagyi Waterspout Nomogram (SWN) which is an empirical method used to forecast waterspouts over the Great Lakes of North America (Szilagyi, 2005). The KHS –Index was developed by Jacob Kuiper in cooperation with Menno van der Haven from KNMI (Kuiper and van der Haven, 2007).

2. About the ALADIN model

ALADIN (Air Limitee Adaptation Dynamique development InterNational) is a limited-area model (LAM) built on the basis of the global IFS/ARPEGE model. The output surface wind fields from the 8-km resolution Croatian domain have been dynamically adapted to orography with a 2-km resolution. ALADIN model data are used to compute SWN and KHS for waterspout events in 2010.

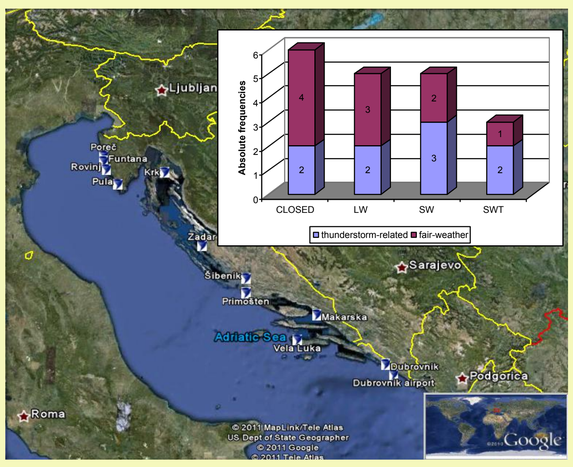
3. SWN and KHS indices

•The KHS index is based on four criteria: wind shear 0-3 km (wind speed only), lapse-rate 0-500 m, average humidity 0-1 km and 10 m wind speed.
•For the Szilagyi Waterspout Index (SWI) the combination of three parameters correlates strongly with waterspout events: water surface – 850 mb temperature difference (ΔT – instability parameter below 1500 m), convective cloud depth, EL-LCL (ΔZ) and 850 mb wind speed (W850). This three parameters are used in the waterspout nomogram (SWN).



4. Waterspout cases of 2010

•19 cases: 7 before noon, 3 around noon, 8 in the afternoon, 1 in the night
•approximately 50% are thunderstorm related, other are fair-weather
•most frequent is CLOSED low synoptic type
•SWN successfully forecasted 14 of 19 waterspout cases (hit rate of 73.7%), KHS 13 of 19 (hit rate of 68.4%) but not all are significant

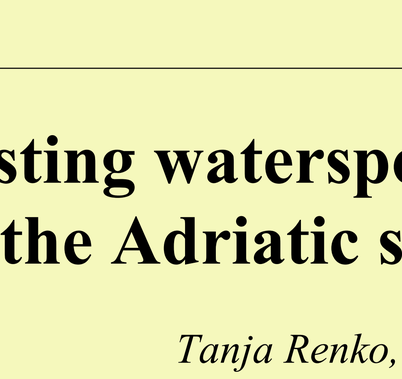


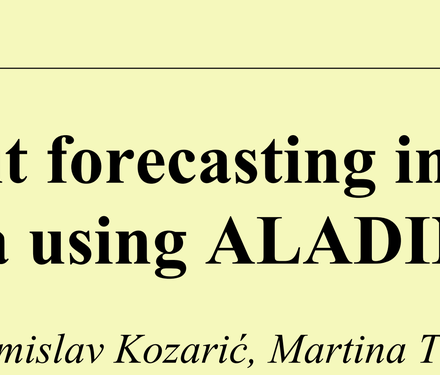
5. Summary/conclusion

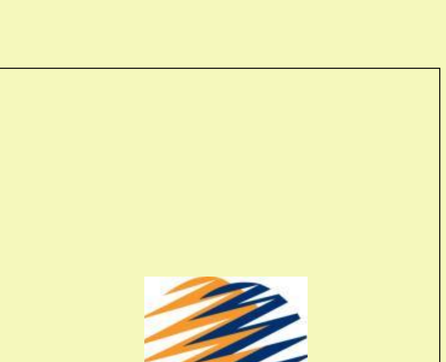
The research shows that most of the analyzed waterspout events were thunderstorm related; however, for those that were not (fair-weather) more than just common thermodynamic instability indices like Totals-Totals Index, KI Index, etc. are needed. Our study shows that SWI and KHS indices improve the waterspout forecast. Still there is a need to collect more cases and to make a climatology of waterspout occurance. Also in our further work we plan to calibrate the KHS Index to our climate and to implement real sea surface temperature.

6. References

•Keul et al., 2009. Prognosis of Central – Eastern Mediterranean waterspouts, Atmospheric Research 93,426-436
•Szilagyi, W. 2005. Waterspout Nomogram Instruction, Internal manuscript. Meteorological Service of Canada, Toronto
•Kuiper, J., van der Haven , M., 2007. The KHS Index, a new index to calculate risk of (water) spout development. Poster, 4th ECSS Trieste, 10-14 September



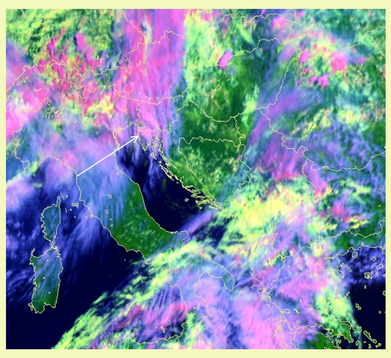


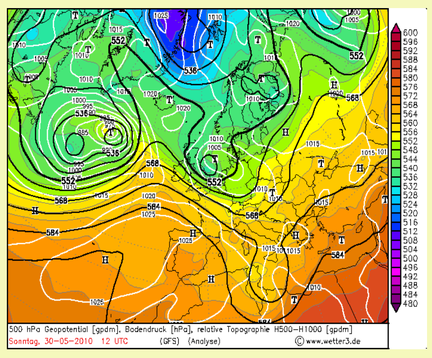


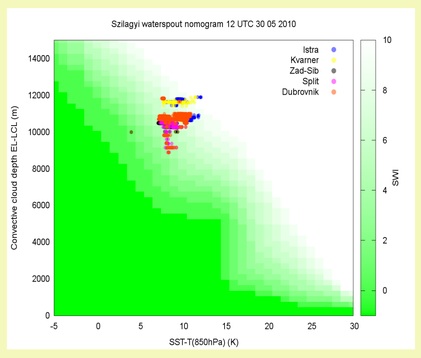
From left to right: Meteosat 9 RGB (0.6, 1.6, 10.8 µm); GFS AT500 hPa, MSLP, RT 500/1000; SWN; KHS for 1.1.2010. 12 UTC

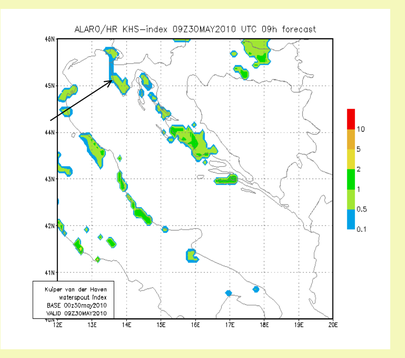
01 January 2010

The waterspout was observed between Makarska and the island of Hvar at 12.40 UTC. There was a single well developed vortex that was connected to the base of a large convective cloud. Convection was associated to strong southwesterly flow in the middle troposphere at the leading side of a trough extending from Alpine region to North Africa. At the surface a cold front was passing from southwest connected to the low in the Gulf of Genoa. Thermodynamical enviroment was favorable for waterspout development (KI near 30, TT over 51). In this case the KHS Index gives no values but the SWN for the area of interest (magenta dots) gives very good results, giving favorable conditions for warespouts.





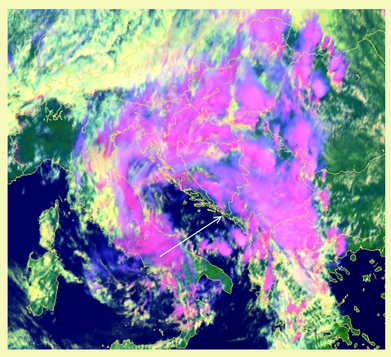


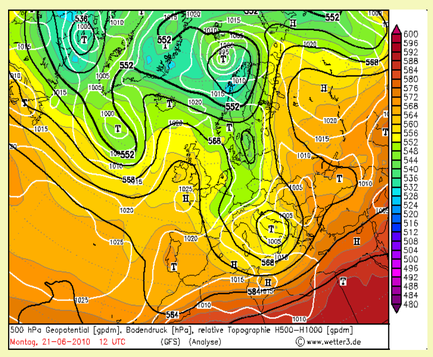


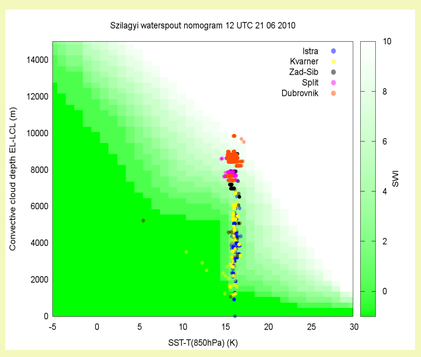
From left to right: Meteosat 9 RGB (0.6, 1.6, 10.8 µm); GFS AT500 hPa, MSLP, RT 500/1000; SWN; KHS for 30.5.2010. 12 UTC

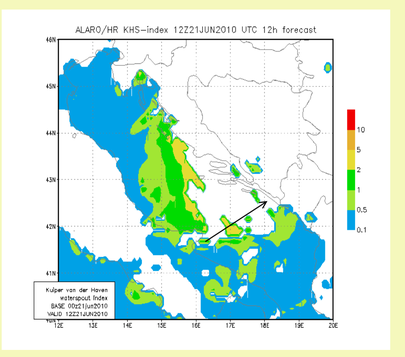
30 May 2010

The waterspout activity was observed in the middle of the day in the vicinity of town Poreč. The interesting thing was long duration of the waterspout from which we can conclude that multi-vortex event happend. As in the previous case this event was also connected to a well developed deep convective cloud, associated to prefrontal cloud band with the surface cold front and the line of convergence just passing the Alpine region. The dominant flow was southwesterly due to short wave trough in the upper levels. In the North Adriatic vorticity advection (PVA) maximum was present, connected to left exit region of a jet streak, which was surely enhancing the convection. Again the KHS index failed because the values where to small in the region of interest, but the SWN gives favorable conditions for even thunderstorm related waterspouts over the whole Adriatic, especially in Istra region (blue dots).





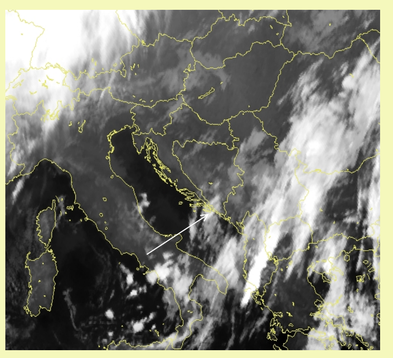


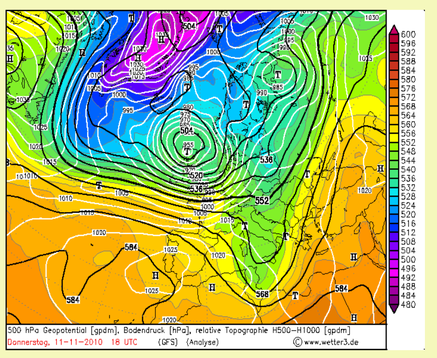


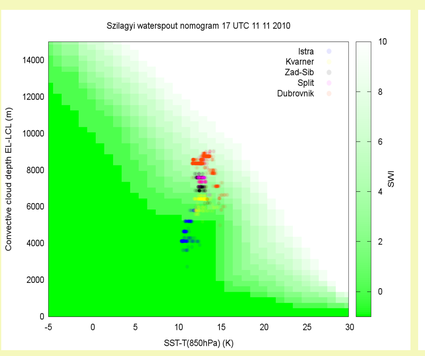
From left to right: Meteosat 9 RGB (0.6, 1.6, 10.8 µm); GFS AT500 hPa, MSLP, RT 500/1000; SWN; KHS for 21.6.2010. 12 UTC

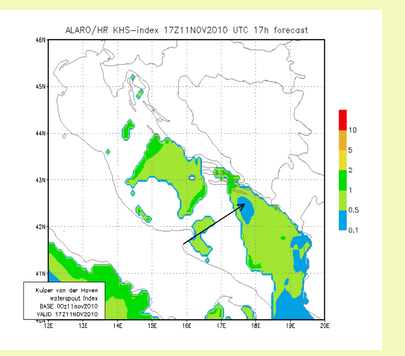
21 June 2010

The first day of summer 2010 in the Adriatic was also recorded as a day with waterspout activity. This time waterspout was observed near Dubrovnik airport in the southern Adriatic in the early afternoon hours lasting for 17 minutes. There was a closed low present over the Adriatic and a cold front has just passed the Dubrovnik area. In the middle troposfere cold advection connected with presence of cold core, together with positive vorticity advection in the region, set favorable conditions for instability. In comparison with previous two analysed cases, the KHS index in this case show some signifcant values (higher than 1) in the upstream area, but also not as high as could be expected. SWN gives positive waterspout potential in the Dubrovnik area (red dots), again performing as good predictor of conditons favorable for waterspouts.









From left to right: Meteosat 9 RGB (0.6, 1.6, 10.8 µm); GFS AT500 hPa, MSLP, RT 500/1000; SWN; KHS for 11.11.2010. 17 UTC

11 November 2010

The one of two November cases was reported near Dubrovnik around sunset, so we assume it was around 17 UTC. According to satellite image at 17 UTC there was some cloudiness near Dubrovnik, however not deep convective clouds, because there was no lightning activity around the time of interest. It seems that the waterspout was connected to a line of cumulus congestus clouds, so can be treated as fair-weather as defined in literature. The 500 hPa analysis chart shows long wave trough oriented north to south with axis crossing central Adriatic. A thermal trough axis was just a little bit to the west meaning that cold advection was present in mid-levels. The sounding from station of Brindisi at 12 UTC showed no CAPE in the upwind, however some instability existed according to KI being a little less then 30 and TT index around 50. Again KHS waterspout index shows marginal values around 1 and SWN for Dubrovnik area (red dots) fulfills conditions for waterspout development, not necessary thunderstorm related, as was this case.